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Workload, Stress, and Situation Awareness of Soldiers Who are Controlling Unmanned Vehicles in Future Urban Operations

by Bruce S. Sterling and Chuck H. Perala

ARL-TR-4071 April 2007

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Human Research & Engineering Directorate, ARL

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14. ABSTRACT

This research describes the workload, stress, and situation awareness of operators of robotic reconnaissance platforms who are conducting future full spectrum operations in an urban setting. The participants controlled unmanned aerial vehicles, unmanned ground vehicles, and unmanned ground sensors in a virtual reality simulation as part of a combined arms battalion using Future Combat Systems. Results suggested that robotic controllers supporting infantry units had higher workloads and stress than controllers supporting non-line-of-sight cannon units, mounted combat system units, or reconnaissance units, perhaps because infantry units are more vulnerable and require closer surveillance. Also, individuals controlling all three sensor types had higher workloads and stress than those controlling other combinations of assets. Human factors recommendations for the interface included an ability to automatically track a target, switch to tele-operation to make slight adjustments, an auto-scan function on the sensor, and the ability for the platform to automatically plot a route to a grid location. Some potential limitations of this study include the fact that the workload may have been affected by other factors such as experience or training; the robotic platforms may have been operated simultaneously or sequentially; and the interface used in this study may or may not mirror the (to be determined) future interfaces.

15. SUBJECT TERMS

autonomous driving; crew workload; live simulation; stress; virtual simulation

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1. Introduction

1.1 Project Background

Previous research on the control of robotic sensors in a virtual environment shows that control of multiple robotic sensors results in higher workload levels than control of single robotic sensors (Chen, Durlach, Sloan, & Bowens, 2005). The same research also indicates that operators detect no more targets with three robotic sensors than with one. Furthermore, fewer participants completed the mission within the time limit using three sensors versus using only one, possibly because of the increased workload associated with controlling three robotic sensors simultaneously. These findings parallel those of Dixon, Wickens, and Chang (2003) who found that pilots controlling two unmanned aerial vehicles (UAVs) detected fewer targets than pilots controlling one UAV. Similarly, Rehfeld, Jentsch, Curtis, and Fincannon (2005) found that in a virtual urban environment and in difficult scenarios, operators detected fewer targets operating two robotic sensors than when operating only one.

The type of task performed also affects operator workload. Schipani (2003) found that terrain that is difficult to navigate as well as changes in terrain resulting from inclement weather affect robotic operator workload so that the more difficult the terrain and the more changes attributable to weather, the higher the operator workload. Generally, missions requiring the sensor to travel longer distances also result in higher operator workload. Additionally, more deliberate missions (requiring cautious approaches) result in higher operator workload. Parasuraman, Galster, Squire, Furukawa, and Miller (2005) found that operators controlling simulated robots in a computer game had higher workloads when opposing forces were organized in a defensive formation versus an offensive formation.

Modern combat frequently involves asymmetrical operations. Instead of fighting enemy forces consisting of brigades, battalions, companies, and platoons, oriented on attacking or defending traditional objectives, coalition forces are often doing battle with small groups of insurgents who quickly appear, strike at a target, and then blend in with the local populace. This type of small group operations is quite different from traditional warfare. The demands on reconnaissance assets in asymmetrical operations are quite different from setting up observation posts or traditional route reconnaissance. The demands on Soldiers operating robotic reconnaissance assets such as UAVs, unmanned ground vehicles (UGVs), or unmanned ground sensors (UGS) in these types of combat operations are not well known.

The workload, stress, and situation awareness (SA) involved in supporting different types of units (e.g., artillery, infantry, armor, reconnaissance) during asymmetrical operations are consequently not well known. For instance, is the workload heaviest during tasks such as locating pin-point targets for artillery (non-line-of-sight [NLOS] units), doing reconnaissance for improvised

explosive devices (IEDs) on a route, locating rocket-propelled grenade (RPG) teams for armor (mounted combat system [MCS]) units, or providing over-watch for an infantry platoon during a raid? Is the workload for some of these units unacceptable?

The workload, stress, and SA involved in controlling different types and numbers of robotic assets during asymmetrical operations are also not well known. The literature suggests that workload associated with operating multiple assets is higher than for operating a single asset, but how much higher, and when does it become unacceptable? Also, what assets or pairs of assets generate the heaviest workload?

1.2 Research Objective

To examine these issues, exploratory research (versus hypothesis-driven research) was conducted with the objective of determining the workload, stress and SA of universal controller (UC) operators during control of robotic reconnaissance entities. Further, we attempted to examine workload, stress, and SA of these UC operators as a function of the type of unit they supported, and the number and type of robotic assets they controlled.

2. Method

2.1 Apparatus

2.1.1 Universal Controller

The UC station used in this experiment consisted of a keyboard, mouse, joystick, and monitor. Figure 1 shows the UC used during this study. The UC operators used the mouse to select the robotic asset they were going to control (one at a time) from a menu of possible assets assigned to them. Robotic assets included UAVs, UGVs, and UGS. After the asset(s) were selected, the UC operators then used the mouse to plot the route for the robotic asset on a situation map displayed on the monitor. They could then use the keyboard to assign the altitude (if a UAV), speed, and radius of the surveillance circle (if a UAV) when the sensor reached its location. After the route and other attributes were assigned, the robotic asset automatically followed the assigned route. If the sensor detected a potential target, it placed an icon of the target on the situation map. A view of what the sensor's camera was currently displaying was also available on the monitor. Operators could use the joystick to control the camera view. After operators detected, classified, recognized, or identified the target, they provided a verbal report up the chain of command concerning the target.

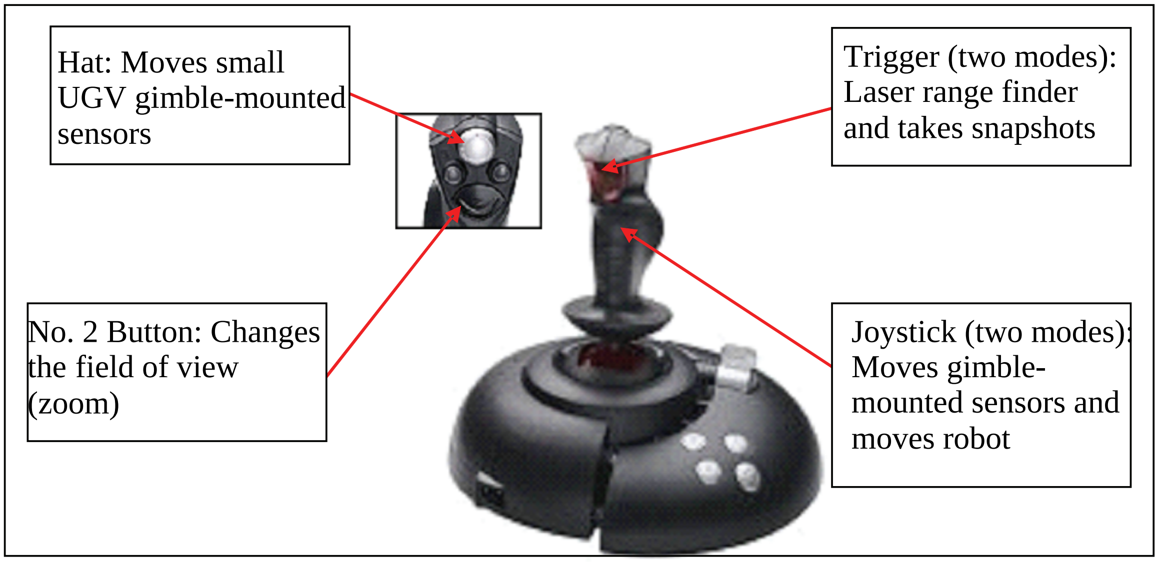

Figure 1. Universal controller.

2.2 Surveys

2.2.1 Demographics

A brief demographic survey was administered to collect background data such as gender, age, rank, time in service, and experience with operating robotic entities and various control devices. The survey is included in appendix A.

2.2.2 Workload

To measure subjective self-ratings of perceived workload, the National Aeronautics and Space Administration (NASA)-Task Load Index (TLX) was used. The NASA TLX (Hart & Staveland, 1988) is a multi-dimensional rating procedure that derives an overall workload score based on ratings from six subscales. The subscales include Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. Each subscale is rated on a 20-point scale, with a total possible workload of 120. Ratings were collected via questionnaires. This instrument is included in appendix A.

2.2.3 Stress

One-item rating scales measuring physical stress and mental stress were used. These measures were used in previous research involving future equipment (Perala & Sterling, 2006). These scales are also in appendix A.

2.2.4 Situation Awareness

The measure of SA used was a variation of the China Lake Situation Awareness (CLSA) rating scale developed by Adams (1998). The original CLSA is a five-point scale developed by the Naval Air Warfare Center to measure SA in flight. The version used here is a 10-point scale adapted to measure SA more generally. This measure is shown in appendix A.

2.2.5 After-Action Review (AAR)

An AAR was conducted to examine human factors issues with the interface and workload. The questions and responses are in appendix B.

2.3 Participants

There were 12 participants for this effort, consisting of nine males and three females. Ten were active duty Army Soldiers and two were civilian contractors. Of the ten military, three were military occupational specialty (MOS) 19K (armor crewman), three were 96B (intelligence analyst), two were 13F (fire support specialist), one was 15K (aircraft components repair supervisor), and one was 25U (signal support systems specialist). Of the military participants, three were Sergeants (E5), five were Staff Sergeants (E6), and two were Sergeants First Class (E7). Mean age was 30 years, mean time in service and MOS (for military) was 9 years, with 28 months mean time in current grade. Nine participants had been deployed to a combat zone, with eight in Iraq and one in Afghanistan. Mean time in the combat zone was 13 months. Of the eight who reported dominant hand, seven were right handed. Of the 11 who reported whether they smoked, nine did not. Participants had taken part in an average of 4.4 prior virtual reality experiments. Type of experience with controlling robotic entities is reported in table 1. Most had at least some experience controlling unmanned vehicles (UVs) using fixed UCs, other joystick UCs, controlling simulated UVs, and in computer games where a vehicle is controlled. Half had experience controlling live UVs in non-operational settings. Only a third had any experience using dismounted UCs or controlling live UVs in an operational setting.

Table 1. Experience with UCs and UVs.

Amount of Experience	Fixed UCs	Dismounted UCs	Other Joystick UCs	Simulated UVs	Live UVs - Operational Setting	Live UVs – Non Operational	Games Where a Vehicle is Controlled
None	2	8	2	2	8	6	0
Basic	3	1	3	0	2	1	3
Intermediate	3	2	4	7	1	3	4
Advanced	4	1	3	3	1	2	5

2.4 Training

Participants received 1 week of training operating the specific UC used in this experiment. This training involved supporting counter insurgency operations in a future brigade combat team organization. No formal test was given, but trainers ensured that all participants acquired basic

proficiency with the system. However, it is possible that because of the level of previous experience, some participants were more proficient operators than others. The scenario, forces, and missions are described next.

2.5 Procedure

The human-in-the-loop (HITL) III experiment at the Fort Knox, Kentucky, Maneuver Battle Lab was part of a virtual experiment, which involved numerous sites, called “Urban Resolve”. The scenario (“road to war”) for Urban Resolve, which will take place in the 2015 to 2016 timeframe, is as follows: Operation Iraqi Freedom ends in 2009, with the establishment of a viable Iraqi democracy. In 2010, Baghdad is stable and prosperous. The prosperity led to an influx of poor, rural immigrants from throughout Iraq. By 2012, the infrastructure of Baghdad deteriorates under its population load, and the central government is not adequately funding its repair and upgrade because of funding of projects elsewhere in Iraq. By 2013, the Baghdad local government is seeking greater economic control and political autonomy. By 2014, the majority of the Baghdad local government resigns and becomes a core of a growing insurgency. By 2015, the government of Iraq asks the United Nations (UN) for help in quelling the growing insurgency and restoring order to Baghdad. A UN task force deploys in April 2015 and within 5 days completes major combat operations, defeating organized resistance. In May 2015, 30 days after the end of major combat operations, stability operations are complete. This is the beginning of Urban Resolve and HITL III.

In HITL III, a combined arms battalion (CAB), as part of a future brigade combat team (FBCT) played at the Fort Knox Maneuver Battle Lab, engages in full spectrum operations, which include combat operations, reconstruction, protection, and humanitarian assistance. Specific missions include anticipating and reacting to improvised explosive devices (IEDs), mortar attacks, kidnappings, and small-scale direct attacks on coalition forces. Opposing forces were loosely organized groups of Iraqi insurgents and foreign fighters. The CAB consisted of a headquarters company, a reconnaissance troop, two MCS companies, two infantry companies, and a mortar battery. The CAB was assisted by an NLOS battalion, consisting of a headquarters company and three NLOS batteries. Except for the UC operators, the remainder of the forces were played in constructive simulation, meaning that there were role players for unit commanders (battalion and company level), and that the forces were actually controlled by research assistants.

For 8 days, (Monday through Thursday of two consecutive weeks) participants operated their UCs from approximately 0900 to 1600, with a 1-hour lunch break. At the end of the day, the participants completed the three brief surveys (workload, stress, and SA), based on their activities that day. Baseline surveys for workload, stress, and SA were completed on the first day. These surveys captured “baseline” data related to a normal day driving to work. An AAR concerning human factors aspects of operating the UCs was also conducted on the eighth day of the exercise.

2.6 Analyses

Because of the small number of participants, the fact that type of unit supported and type of asset(s) controlled were not manipulated as independent variables, and the fact that not all participants completed a survey each day (for various logistical reasons), only descriptive statistics were reported. Mean workload, stress, and SA were examined by type of unit supported and by type of robotic asset(s) controlled.

3. Results

3.1 Workload

3.1.1 Workload by Type of Unit Supported

Figure 2 presents overall workload by type of unit supported. Compared to baseline, only supporting infantry, reconnaissance, and multiple units resulted in higher workload. Supporting infantry units result in the highest workload, although that is still less than half of the possible maximum workload (120).

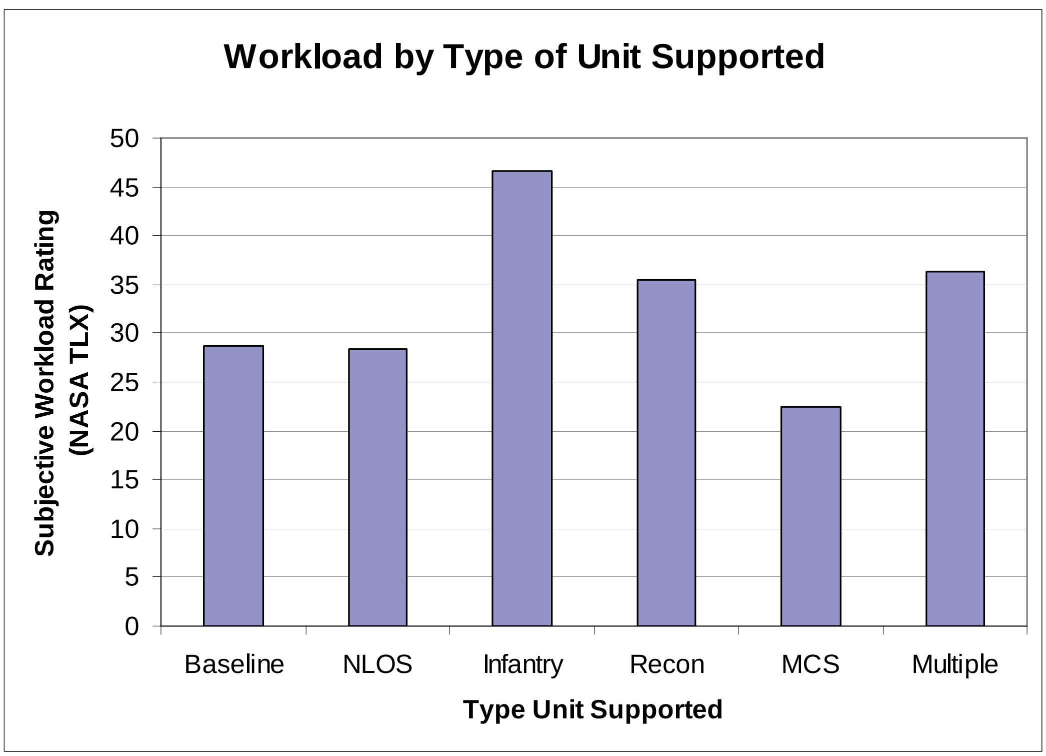

Figure 2. Overall workload by type of unit supported.

Individual scale ratings of workload by type of unit are presented in table 2. For infantry units, the only means that exceed baseline by a factor of two or more are for mental workload (thinking) and temporal workload (time pressure). For operators supporting multiple types of units, performance workload (poor performance) also exceeded baseline by a factor of two.

Table 2. Workload scales by type of unit supported.

Type Unit	Mental	Physical	Temporal	Performance	Effort	Frustration
Baseline (n=11)	2.64	2.27	3.55	3.83	8.36	8.09
NLOS (n=15)	3.07	3.33	3.13	2.80	13.86	2.27
Infantry (n=17)	12.27	2.59	8.29	3.71	10.29	9.12
Recon (n=23)	4.43	1.48	4.65	5.83	7.69	11.09
MCS (n=12)	2.33	1.67	2.25	3.75	8.50	4.00
Multiple (n=3)	5.33	1.67	6.33	10.33	4.67	8.00

3.1.2 Workload by Type of Asset(s) Controlled

Figure 3 presents overall workload by type of asset(s) controlled. Only workload for operating UAV plus UGS and workload for operating all three types of assets (UAV, UGV, and UGS) exceeded baseline workload. Workload for operating UAV plus UGS exceeded baseline workload by 27%, while workload for operating all three types of assets exceeded baseline workload by 87%. Again, even so, workload for operating all three assets does not reach half the maximum possible workload levels (120).

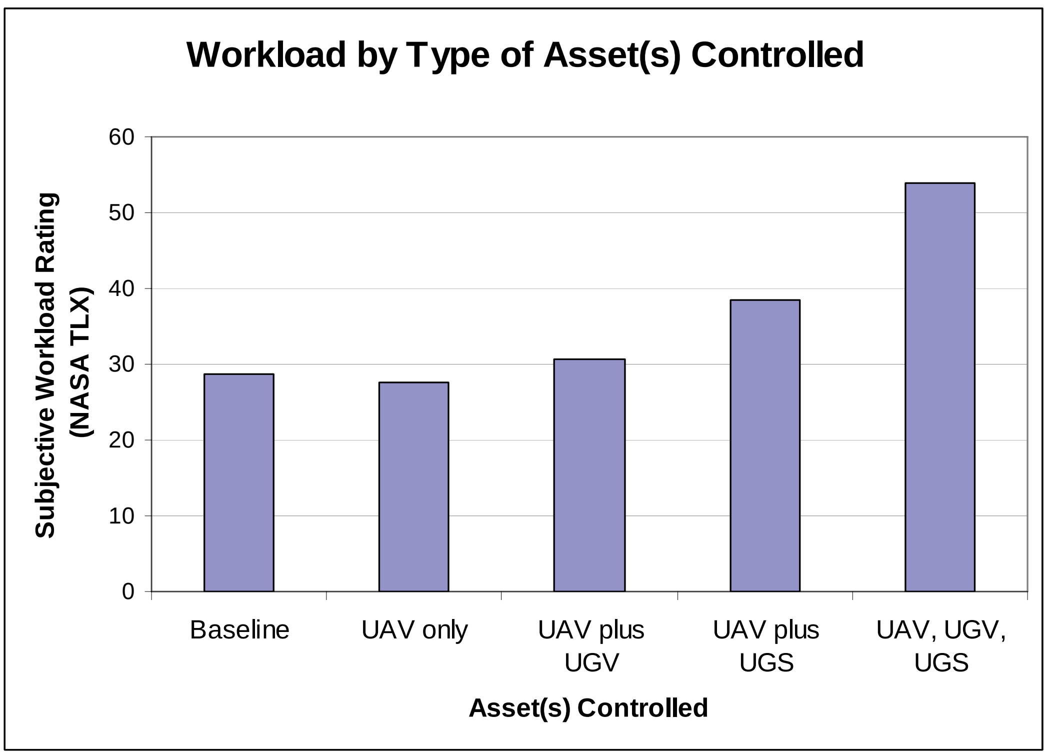

Figure 3. Workload by asset(s) controlled.

Individual scale ratings of workload by type of asset(s) controlled are presented in table 3. For the UAV plus UGV and UAV plus UGS, the mental (thinking) workload was more than twice the baseline level but was still low compared to the maximum level (20). For operating all three robotic platforms, the mental (thinking) workload exceeded baseline levels by a factor of four, and temporal (time pressure) exceeded baseline levels by a factor of nearly three; both were more than half of the maximum possible workload (20). Effort was more than half the maximum possible workload (20) for operating all platforms but UAV and UGV only. However, baseline effort was also reported as relatively high.

Table 3. Workload subscales by asset(s) controlled.

Asset(s) Controlled	Mental	Physical	Temporal	Performance	Effort	Frustration
Baseline (n=11)	2.64	2.27	3.55	3.83	8.36	8.09
UAV Only (n=36)	2.94	2.08	2.58	3.33	10.09	6.64
UAV plus UGV (n=12)	6.83	2.00	5.50	6.42	5.42	4.42
UAV plus UGS (n=7)	6.14	2.57	5.00	3.14	10.43	9.14
UAV, UGV, UGS	11.36	2.21	10.57	6.64	11.86	11.21

Since workload was higher for infantry units than other units and since workload was higher for operators using all three platforms than for other assets, it is possible that the “interaction” of operators using all three assets in infantry units is responsible for both findings. To examine for that possibility, we crossed all types of units with all assets controlled, although operators in all types of units did not report controlling all types of assets.

Table 4 shows that for the only asset controlled by all types of units (UAV only), controllers in infantry units had the highest workload. In fact, for the three types of assets that operators in infantry units controlled, infantry unit operators had the highest workload of any type unit for two of those three assets (UAV only and UAV, UGV, plus UGS). Also for the units that controlled all three assets (all but NLOS units), workload was always highest for controlling all three assets, compared to any other asset class. Thus it appears that type of unit (infantry) and type of asset(s) controlled (all three assets) each separately contributed to the workload.

Table 4. Workload by type of unit and asset(s) controlled.

Type Unit	UAV Only	UAV plus UGV	UAV plus UGS	UAV, UGV, UGS
NLOS	25.6	-	46.0	-
Infantry	37.0	28.5	-	61.9
Recon	32.7	35.5	39.3	48.5
MCS	12.2	-	30.3	35.3
Multiple	21.0	32.0	-	56.0

3.2 Stress

3.2.1 Stress by Type of Unit Supported

Figure 4 presents stress levels by type of unit supported. The only levels to exceed baseline were mental stress for infantry, reconnaissance, and multiple types of units. Only infantry units exceed baseline mental stress by a factor of two. This parallels the findings for workload.

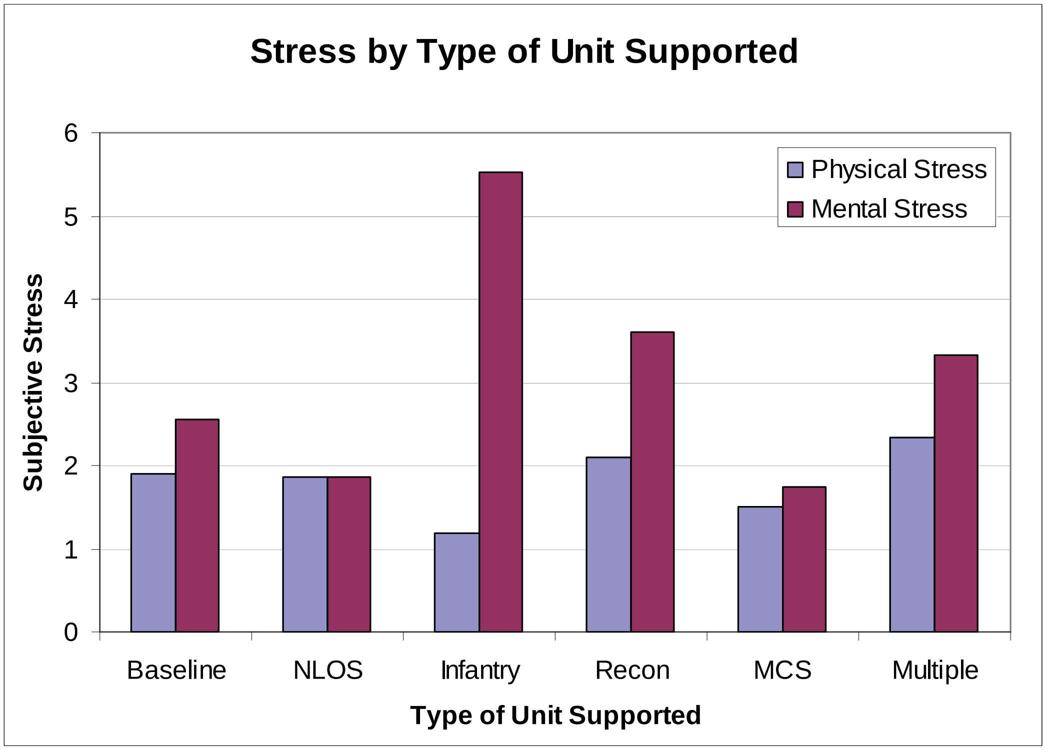

Figure 4. Stress by type of unit supported.

3.2.2 Stress by Type of Asset(s) Controlled

Figure 5 presents stress data by type of asset(s) controlled. Results for mental stress closely parallel workload data, showing stress above baseline levels for all asset classes except UAV only. Like workload, mental stress for operators using UAV plus UGS exceeds baseline mental workload by 73% and mental workload of operators of all three assets exceeds baseline by a factor of two.

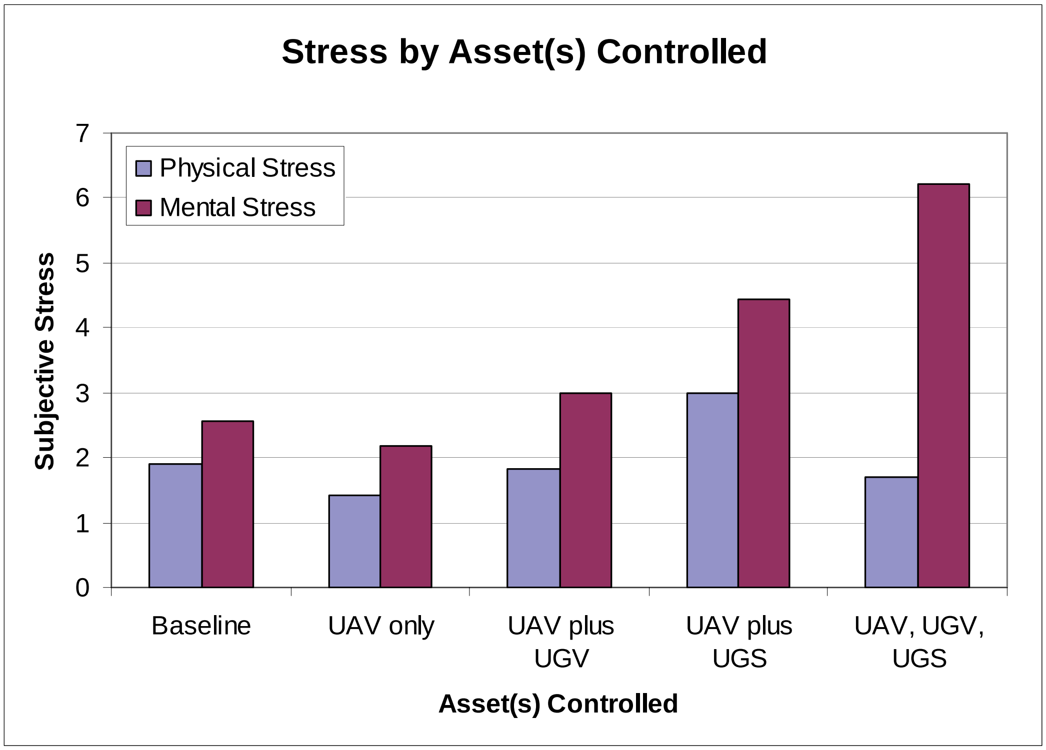

Figure 5. Stress by type of asset(s) controlled.

3.3 Situation Awareness

3.3.1 SA by Type of Unit Supported

Figure 6 contains data on SA by type of unit supported. The SA data are to some extent the inverse of the workload data, with SA being higher for units where operators report lower workload (NLOS and MCS) and SA being lower for units where operators report higher workload (infantry and reconnaissance). The SA is lowest for controllers in reconnaissance units.

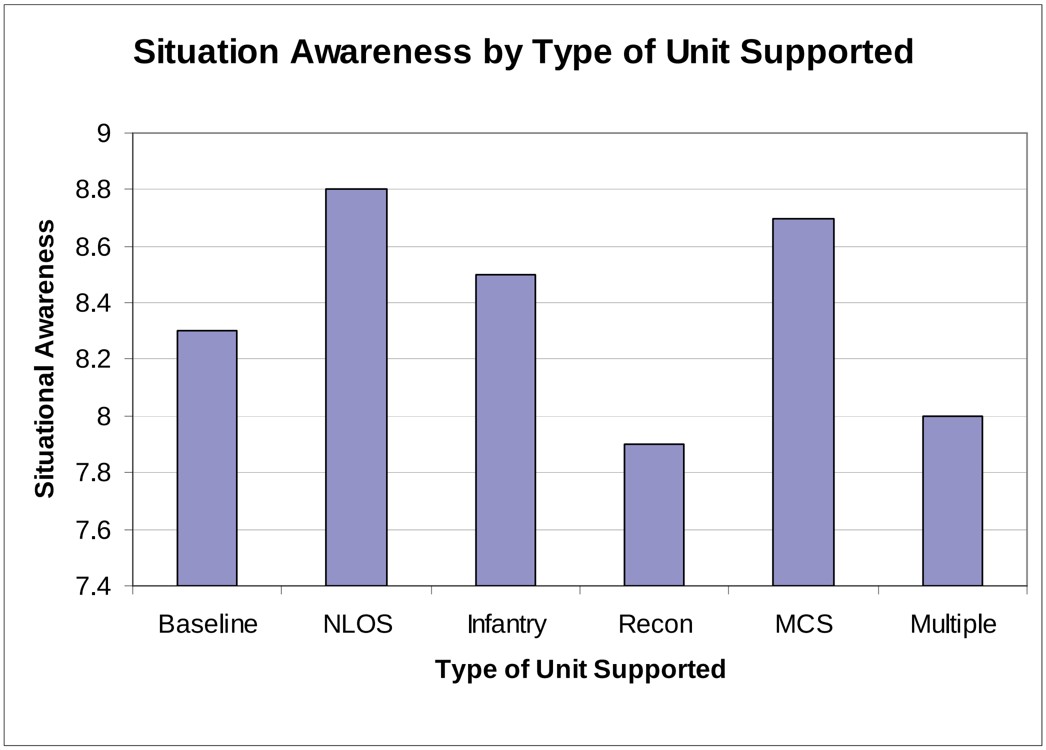

Figure 6. SA by type of unit supported.

3.3.2 SA by Type of Asset(s) Controlled

Figure 7 contains data on SA by type of asset(s) controlled. The only type of asset were SA is lower than baseline is SA for operators controlling the UAV plus UGS.

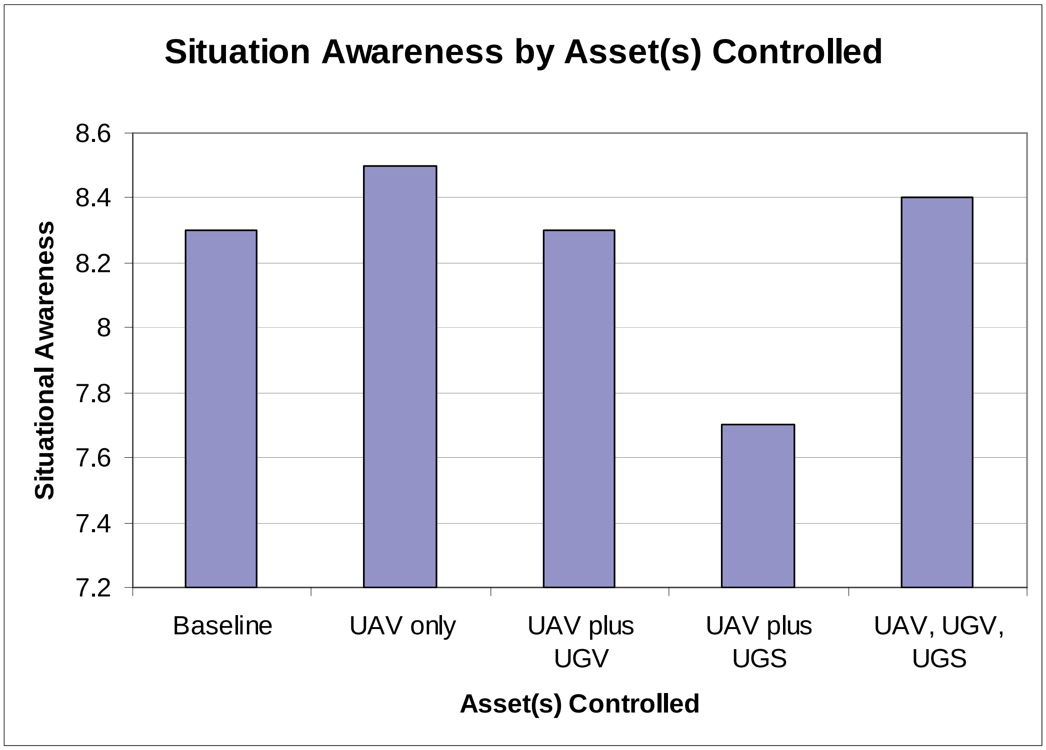

Figure 7. SA by type of asset(s) controlled.

3.4 AAR Comments

Human factors issues mentioned in the AAR were that (a) one could not lock the camera onto a target (location or building) but had to constantly use the joystick as the platform moved or UAV circled; (b) one could not make minor adjustments in the path of a sensor platform; if one wanted to have a sensor platform move a few meters right or left, one had to re-plot the route; and (c) UGS sensors were constantly going off. This latter comment could explain why using UAV plus UGS exhibited the second highest workload and low levels of SA.

Improvements recommended were automatic target tracking (as mentioned before), an auto-scan capability (operators had to manually move the camera), having a sensor automatically plot a route to a grid coordinate, being able to tele-operate the sensors for "fine tuning their routes" (as implied before), and a hovering capability for UAVs.

Surprisingly, given the workload data, the most difficult sensor platform to control was the UAV. Answers for the maximum number of sensors to control simultaneously ranged from 2 to 4, if monitoring sensor view was considered part of controlling the sensor.

4. Discussion

Workload (particularly mental and temporal) and mental stress were highest for operators assigned to infantry units. This may be because dismounted infantry operations are more vulnerable than those of NLOS units operating farther from danger, mounted (MCS) units, or reconnaissance units, who have robotic assets to put in harm's way. Dismounted infantry would generally be more vulnerable to IEDs or snipers than other types of units and thus demand more thorough vigilance from sensor operators. This finding parallels Schipani's findings that more deliberate missions (requiring cautious approaches) result in higher operator workload.

As with the previous literature, workload (particularly mental and temporal) and mental stress were also much higher for operators controlling all three types of robotic assets. It seems that switching attention between two types of assets is not substantially more demanding than one asset or the baseline task (driving familiar terrain), but when attention sharing among three assets is required, workload increases substantially.

Although workload and stress for type of unit and type of sensor controlled were separate effects, it did appear that they were additive. For example, mental workload for participants operating all three types of sensors for infantry units averaged 16.4 (of a possible 20) and mental stress averaged 8.25 (of a possible 10)—much higher than reported by any other operators and possibly sufficient to degrade performance.

Human factors issues centered on controlling the sensor's camera view. A target-tracking capability and auto-scan capability for the camera were two desired capabilities, as well as ability for the UAV to hover or to tele-operate the sensor platform to change the camera view by a few meters. Monitoring as many as four camera views was about the most workload operators thought they could handle.

Workload is likely to be affected by experience with the UC. We subsequently examined the experience, as reported on the demographic survey, of participants supporting infantry units and reporting higher levels of workload. Compared to other participants, these participants reported equivalent levels of experience with controlling unmanned platforms in simulation but lower levels of experience with controlling live unmanned platforms, either in operational or non-operational (experimental) settings. Thus perhaps some of the higher levels of workload reported resulted from lack of experience with live unmanned platforms and the levels of workload entailed in using those platforms.

Our interviews did not focus on why workload was reported to be higher or lower. Thus, it is possible that workload was affected by lack of experience, problems with the network, type of supervision or other factors that happened to co-vary with supporting infantry units.

Workload increases with the number of unmanned platforms reported to be operated but does not approach maximum workload (120) even with control of three platforms. However, because of the non-experimental design of this research, there is no indication whether the multiple platforms were controlled simultaneously or sequentially. Individuals with extensive simulation experience in the Maneuver Battle Lab suggested that simultaneous control of more than one unmanned platform is extremely demanding.

Since the design of the actual interface for future combat systems (FCSs) has yet to be determined, the relationship of the workload of the system used in this research to the workload of the system used in FCS cannot be stated with any accuracy. Although some aspects of the system, such as waypoint navigation versus necessity of tele-operation, are undoubtedly similar to those of the future system, it is difficult to predict whether the future system interface will be designed in a more or less user-friendly manner than the system used in this research.

Future research should attempt to take the noted issues into consideration. For instance, workload of individuals reporting much experience with unmanned platforms should be compared to work-load of individuals reporting little experience to gauge the effects of experience on workload. Interviews with participants should focus on what factors other than those undergoing study affected workload (e.g., lack of training, problems with the network, other responsibilities, etc.). Also, observations and interviews should attempt to determine whether unmanned platforms were generally controlled simultaneously or sequentially. Ideally, experimental controls for these variables should be implemented, if possible. Finally, experimenters should attempt to acquire or replicate interfaces intended to be used in FCS so that results will be as predictive as possible to results with the future systems.

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Appendix A. Surveys

Demographic Questionnaire

Participant ID (last 4-ssn):________________ Date:___________________

General:

1. DOB: ________ 2. Sex: M / F 3. Height: _______ft. ________in.

4. Weight: _________ lb. 5. Handedness: Right / Left 6. Smoker: Y / N

7. Rank: __________

8. Time in service: Yrs:______Mos:______

9. Time in grade: Yrs:______Mos:______

10. MOS/Specialty: ______________________

11. Time in MOS/Specialty: Yrs:______Mos:______

12. Combat experience: Y / N If Yes, Where? __________________ How long? ________

Experimentation:

9. How many UAMBL experiments (i.e., simulations in the battle lab) have you participated in? (if none, indicate 0): ______________

10. Indicate whether you have had experience, and at what level, for each the following:

a. Use of fixed/stationary Army Universal Controller Unit

____None ____Basic ____Intermediate ____Advanced

b. Use of dismounted Army Universal Controller Unit

____None ____Basic ____Intermediate ____Advanced

c. Use of other, similar joystick-type controller unit

____None ____Basic ____Intermediate ____Advanced

d. Control of simulated unmanned systems (e.g., UAVs, UGVs, other)

____None ____Basic ____Intermediate ____Advanced

e. Control of live unmanned systems under operational conditions (e.g., during combat operations)

____None ____Basic ____Intermediate ____Advanced

f. Control of live unmanned systems in a non-operational setting (e.g., testing, experimentation, etc.)

____None ____Basic ____Intermediate ____Advanced

g. Do you have any experience with computer games where you control a vehicle?

____None ____Basic ____Intermediate ____Advanced

HITL III Universal Controller Surveys

Participant ID (last 4 of SSN): ____ ____ ____ ____

1. Indicate the type of unit to which you were assigned today (e.g., infantry, reconnaissance, armor, etc.)

2. Briefly describe the types of missions that you completed today (e.g., attack of building occupied by insurgents, anti-sniper activities, etc).

3. What types of asset(s) did you control with your universal controller?

____ Unmanned Aerial Vehicle(s) (UAV)

____ Unmanned Ground Vehicle(s) (UGV)

____ Unmanned Ground Sensor(s) (UGS)

4. What problems did you encounter in your ability to control your unmanned system?

Please complete the following **SHORT** surveys (nine questions total) for the missions that you performed today.

NASA TLX Workload Assessment Instructions

We are interested in the "workload" you experienced during this scenario. Workload is something experienced individually by each person. One way to find out about workload is to ask people to describe what they experienced. Workload may be caused by many different factors and we would like you to evaluate them individually. The set of six workload rating factors was developed for you to use in evaluating your experiences during different tasks. Please read them. If you have a question about any of the scales in the table, please ask about it. It is extremely important that they be clear to you.

Definitions

Title	End Points	Descriptions
MENTAL DEMAND	Low / High	How much mental and perceptual activity was required (that is, thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	Low / High	How much physical activity was required (that is, pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	Low / High	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	Poor / Good	How successful do you think you were in accomplishing the goals of the task? How satisfied were you with your performance in accomplishing these goals?
EFFORT	Low / High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	Low / High	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

We want you to evaluate workload for the missions that you participated in today. Rate the work-load on each factor on a scale. Each scale has two end descriptions, and 20 slots (hash marks) between the end descriptions. Place an "x" in the slot (between the hash marks) that you feel most accurately reflects your workload. This includes all the duties involved in your job (e.g., preparing your workstation, using displays and controls at your workstation).

Date:_______

TLX Workload Scale

Please rate your workload by putting a mark on each of the six scales at the point which matches your experience.

Mental Demand

Very Low Very High

Physical Demand

Very Low Very High

Temporal Demand

Very Low Very High

Performance

Very Poor Very Good

Effort

Very Low Very High

Frustration

Very Low Very High

Subjective Stress Rating Scale

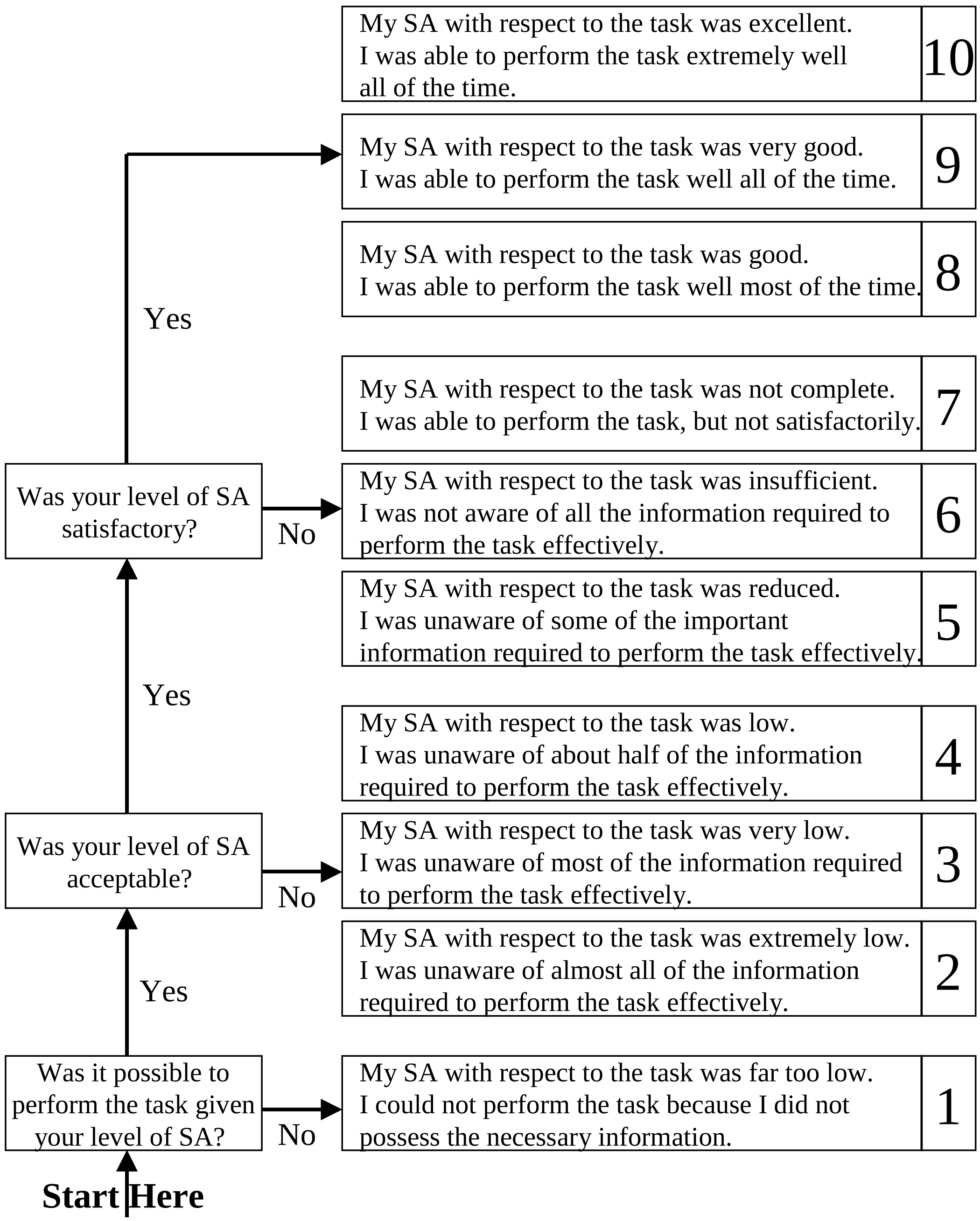
1. The scale below represents a range of how PHYSICALLY stressful the mission might be. Check the block indicating how PHYSICALLY stressful the mission you just participated in was.

Task	Not at All Stressful 1	2	3	4	5	6	7	8	9	Most Possible Stress 10
a. Overall stress										

2. The scale below represents a range of how MENTALLY stressful the mission might be. Check the block indicating how MENTALLY stressful the mission that you just participated in was.

Task	Not at All Stressful 1	2	3	4	5	6	7	8	9	Most Possible Stress 10
a. Overall stress										

Situation Awareness Rating Scale



Appendix B. AAR Questions and Responses

HITL III AAR Comments
26 Oct 06

What problems did you have doing your job with the interface provided?

- Couldn't "lock on" with camera. Needed to continuously adjust camera throughout entire mission. "If we were tasked to watch an area or building, we were not able to 'target lock' on the building or point on the ground, so in order to keep the camera viewpoint in one location, we had to manually keep turning the joystick for the entire duration of the mission." The technicians changed the program to fix this problem, but this happened only a few hours before the entire experiment concluded.
- Could "see" your own UA if you looked down or hard left/right. Could see the bottom of your "legs" in the Class II UA. The image of your UA would flash or flicker and was very annoying and distracting.
- UA would overshoot target, so you needed to reduce your speed in small increments to avoid this.
- No easy way to make minor/incremental adjustment with the UC (OTB okay). I.e., in order to move, say, up a foot or so to see through a window, you couldn't just nudge or move your UA that small distance. Instead, you had to create a whole new route and have the UA follow that new route.
- UGS, IMS, and TCP sensors were constantly going off. Probably a SIM issue, but it really divided our time and attention.

What changes would you make to this interface?

- The camera needs an "auto-scan" capability. The camera is currently independent of the direction of travel.
- Would like to have the ability to input grid coordinates to have a "fly to" or "go to/look at" capability.
- Needs an onscreen compass. Can currently see where you're looking but not where you're going. Difficult to know relationship between UA movement, camera view, and other entities.
- Needs target tracking capability. They were constantly looking at the icon 'properties' to determine what it was.
- Allow us to 'lock on' a target with the camera and then allow us to stay on that target while we look someplace else with another UA. Need multiple screens (like multi-screen surveillance cameras) for each system. We had to keep reacquiring a target/area of interest every time we wanted to use our other UA to look at something else. Reduces SA and increases time and workload currently.

What did you like must about this interface?

- Simple to use.
- The graphics.
- Easier to control UAVs versus ground UAs.

What mission(s) was/were the most difficult to control and why?

- Couldn’t hover with the Class III UAVs. “If I wanted to ‘stop’ and look at something, I had to land it on the top of buildings.”
- “Any mission that the UAVs were used for me. I felt the movement of the camera was slow in the fact that if something was seen on the OTB and I needed to look at with some urgency it wasn't happening.”

What was the maximum number of UAs you think you could have successfully controlled?

- Four if the task was just monitoring
- Two if the task was controlling and monitoring
- Controlling like-systems (i.e., only UAVs or only UGVs) would be easier because camera views are confusing.

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